551

Meat Fats of Better Quality

Waldo C. Ault,
Roy W. Riemenschneider,
Steward G. Morris

The edible meat fats, lard and tallow, are almost completely digestible. They are high-energy foods and contain substances necessary for good nutrition. They also are of great economic importance. Our lard production alone amounts to 2½ billion pounds a year—approximately equal to the combined production of soybean and cottonseed oils.

It seems strange, therefore, that they have received so little attention. Probably that is because they are by-products of the meat-packing industry, or because we regard the rapid expansion in the production of soybean oil as more exciting. Be that as it may, the factors that affect the quality and acceptance of these fats deserve careful consideration.

The properties open to improvement are keeping quality, or stability, physical characteristics—such as plastic range, consistency, and the creaming power—odor, flavor, color, and smoke point (temperature at which a fat or oil begins to smoke).

Stability is the main one. Without better keeping quality, the application of other techniques would have little value, because the best shortening is unfit for use if it has a strong odor or flavor—if it is rancid. The chief causes are atmospheric oxidation, absorption of odors, and the action of enzymes and micro-organisms. Rancidity that is caused by atmospheric oxidation and gives a characteristic pungent odor is responsible for most of the economic losses of fats and fatty foods.

Oxidative rancidity in lard is particularly serious. Moreover, most processing that is undertaken to improve other properties (such as odor and color) tends to reduce the stability of fats. It has been difficult, therefore, to apply the various processing techniques to lard.

Before satisfactory progress could be made in understanding oxidative rancidity and in producing fats of satisfactory stability, methods for predicting stability and evaluating antioxidants were necessary. Reasonably effective methods for accomplishing those ends are available, but because of the many factors involved none of them gives perfectly clear-cut results.

The methods most widely used are the active-oxygen method, frequently referred to as the Swift stability test; oxygen-absorption measurements; incubation tests; and baking tests.

The active-oxygen method involves bubbling purified air or oxygen through the melted fat under standardized conditions, usually at 210° F. The time in hours required to develop rancid odor or a peroxide content indicative of rancidity is noted. To an experienced technologist, this time is of value as a basis for comparison in predicting the life of a fat or in estimating the worth of an antioxidant that may have been added to the fat under test.

By use of suitable equipment, the time a sample of fat requires to reach a level of oxygen uptake preestablished as the rancid point may be determined under standardized and comparable conditions. In this instance also, the time is of value in predicting the storage life of a fat or in estimating the merit of an antioxidant. Workers at the Eastern Regional Research Laboratory reported that results obtained by the method usually lead to the same conclusions as those of the active-oxygen method, but because of manipulation difficulties it is not so generally used.

Keeping quality may also be determined by merely incubating samples of fat in open beakers or jars in an oven at a temperature usually of 145° F., although occasionally higher temperatures are used. A comparison of the time required for rancidity to develop in each sample is a measure of their stability. The rancid point may be detected by sense of smell or by chemical determination of peroxide content.

When an effective antioxidant is added to a fat, the keeping time of the fat before development of rancidity may be increased fivefold to tenfold. The test methods we have described provide an approximate measure of the increase in stability of the fat.

However, only a few of the antioxidants that are capable of protecting the bulk fat will continue to stabilize the fat after it has been used in baked products. In other words, most antioxidants do not have "carry over" into baked goods. Consequently, standardized baking tests have become necessary in evaluating antioxidants for edible fats. In such baking tests, the fat (with or without added antioxidant) is baked in a pastry or cracker recipe and the stability of the products is noted. The methods for determining the stability of fats can also be used in studies aimed at minimizing destruction of the natural antioxidants in fats during processing.

The meat fats have a much lower content of the more effective natural antioxidants than do most vegetable fats. The naturally occurring antioxidants include lecithin, or cephalinlike substances, and tocopherols. Many investigators believe that tocopherols, the effective antioxidant of most vegetable oils, are also present in traces in lard if they are not destroyed by processing. Rather extensive experiments at the University of Minnesota offer little hope for increasing the oxidative stability of the meat fats by feeding an antioxidant substance to an animal before slaughter. The investigators reported that of a wide variety fed, tocopherol was the only antioxidant deposited in the adipose tissue to a significant extent.

In attempting to produce a meat fat of good stability, it is therefore important to conduct the processing operations in such a manner as to minimize destruction of any antioxidant substances present. That means the avoidance of unnecessary exposure of the fat to light, air, or high temperatures. The fat must not be held at high temperatures while exposed to air for long periods. It is also important to keep metal contamination as low as possible. Some metals, in the form of their salts or oxides, are known to have a pro-oxidant effect; that is, they reduce the stability of fats markedly. That is particularly true of iron and copper. In fact, copper is such a powerful pro-oxidant that its addition to the extent of a few tenths of one part per million makes lard rancid in about 20 minutes at temperatures of boiling water.

Copper or copper-bearing alloys, therefore, should not come into contact with the fat during the handling and rendering processes. It is hardly possible to eliminate all iron from the equipment, but elimination of rust, especially following shut-down periods, helps. Increased stability can be obtained by equipping the processing and rendering departments with aluminum, stainless-steel, and glass- or plastic-lined tanks, pipes, and pumps.

A process for removing contaminating metals from fats has been described. The fat is treated with tannic acid and subsequently filtered. The filtration apparently removes the metals and the excess tannic acid.

If metal contamination is not too great, the metal may be deactivated by adding a compound that unites with the metallic ion. Such bound metal has no pro-oxidant properties. Citric acid, esters of phosphoric acid, ascorbic acid, and esters of ascorbic acid and isoascorbic acids are examples of edible compounds that are metal deactivators in fats.

The use of such precautions during processing will result in the production of meat fats with increased stability. The low content of natural antioxidant substances, however, probably precludes the preparation of meat fats that have stabilities such as are usually found in the hydrogenated vegetable-oil shortenings unless some substance that will delay oxidative degradation is added. Besides the natural antioxidants, synthetic compounds that will do this are known. Such substances generally contain or consist of compounds having quinol, phenol, amino, or sulfide groupings.

The mechanism by which antioxidants perform their function is still not clear, but an effective antioxidant is always capable of being oxidized in the medium and under the conditions found in the oxidizing substrate. Usually the antioxidant will be nearly gone before peroxides develop in appreciable amounts and before rancidity can be observed.

A large number of compounds bring about a marked enhancement of the stability when they are added to fats that contain phenolic antioxidants. They are ineffective, however, in substrates devoid of natural or added phenolic antioxidants. The compounds are generally referred to as antioxidant synergists, or simply synergists. The substances most frequently considered acceptable synergists for edible purposes are those already enumerated as effective metal deactivators, such as citric acid and ascorbic acid. On that basis, it would seem that synergistic action could be explained as merely metal deactivation. In many instances, that is undoubtedly true. This single mechanism cannot explain the complete role of synergists, however, for some compounds are known to exert synergistic effect with antioxidants, even when no metals are in the fat.

Synergistic compounds are relatively less expensive than most of the antioxidants. Therefore, their use usually results in important economies. Consequently, most of the lard on the market today that has improved stability contains synergistic antioxidant mixtures.

An ideal antioxidant for use in foods should have the following qualifications:

Effective stabilizing action under conditions of use.

No harmful physiological effect, even in quantities considerably greater than those likely to be used and even when ingested over long periods of time.

At least sufficient solubility in fats to facilitate its use; greater solubility is usually advantageous.

Freedom from objectionable odor, color, or flavor even after storage.

Stability to whatever processing is necessary after it is incorporated in the fat.

Protective action which carries over into baked goods.

Economy in use and availability in amounts needed.

Despite this list of requirements, several substances have been declared acceptable as antioxidants for use in lard in federally inspected plants subject to provisions governing the concentration and statements on the label. The substances include gum guaiac, tocopherol concentrates that contain at least 30 percent tocopherol, nordihydroguaiaretic acid (NDGA), propyl gallate, butylated hydroxyanisole, thiodipropionic acid and lauryl thiodipropionate, corn oil, lecithin, citric acid, and phosphoric acid. The last three are generally considered to have their greatest value when used as synergists. If not already, certainly in the near future, satisfactory antioxidants will be available at low cost. In fact, the cost of some already approved permits significant improvements in stability at a cost of 10 cents or less for 100 pounds of lard.

An inexpensive and simple process for improving the keeping quality of home-rendered lard has been developed at the Eastern Regional Research Laboratory. The process, which is nothing more than the addition of about 5 percent of a hydrogenated vegetable shortening, owes its success to the high content of tocopherols in most vegetable oils. The period during which the lard will remain free from rancidity is nearly doubled. Hydrogenated vegetable shortening can be bought in any grocery.

The addition of antioxidants to lard must not be considered as a cure for all the ills of the industry.

THE USE OF BETTER PACKAGING offers great possibilities for improving the keeping quality and increasing acceptance by those who use this important commodity. A large percentage of the lard sold on the retail market now is packaged in cardboard cartons, chiefly in the 1-pound size. The package permits ready passage of air to the contents. The paper used in the past to make the cartons and their liners often had absorbent properties and took up the liquid part of the lard, somewhat like a wick. Such wicking action separated the liquid part of the fat, which was most susceptible to rancidity, in a way that enormously increased its exposure to the deleterious action of air. More recently, lining papers have been developed which are much better in that respect. They are not very convenient, however, and many users do not like such packages. A completely satisfactory package certainly should be easy to open and close. Packages more acceptable to consumers can be made most readily from rigid, nonabsorbent materials, such as metal or glass. Such packages can be evacuated or flushed with inert gas and sealed and protect the contents better.

Suitable antioxidants for protection of the fat during processing as well as during subsequent storage make possible the application of technological processes for improving it in other ways. The processes can be used to modify the texture, creaming properties, and consistency and to eliminate odor, color, and free acidity.

A fat, such as lard or shortening, at a casual glance, looks like a soft, but more or less homogeneous, solid. But at ordinary temperatures it really consists of a suspension of solid fat particles in a liquid matrix. This physical condition is brought about by the presence of a large number of different glycerides, which have widely varying softening points, so that at any given temperature a part is solid but another part is liquid. The plasticity or workability of a fat depends somewhat on its relative proportions of liquid and solid.

Other factors, not so obvious, that influence the plasticity of a shortening include the size of the solid particles and their tendency to form aggregates—in that respect, the meat fats are quite unlike hydrogenated vegetable shortenings. Lard particularly has the peculiar property of solidifying in such a way that large crystals frequently are formed to give a grainy appearance. The housewife dislikes this; besides, it indicates a rather narrow temperature range of workability, which the commercial baker dislikes.

The lard producer chills the rendered fat as rapidly as possible by mechanical means so that the crystals will be small. Fine crystals extend the plastic range of the product, give it a smooth appearance, and make a product of the maximum degree of firmness. Lard and hydrogenated lard that have large crystals are affected by variations in temperature. Consequently, their plasticity in storage and commercial handling is unpredictable.

Chemical methods for modifying lard to eliminate or minimize graininess have been proposed. The methods are designed to alter the glyceride structure by modifying the characteristic manner in which the fatty acids are combined with glycerol to form the fat. This is accomplished by heating the fat in the presence of a small excess of glycerol or in the presence of a catalyst, such as sodium ethylate. Such glyceride modification or rearrangement tends to bring the consistency and melting point of fat to more definite and reproducible values. Such methods for modifying lard require suitable equipment and considerable scientific control.

Simpler methods are available, fortunately, for increasing the firmness of lard, but they may not offer all the advantages of the techniques we described. Lard stearine or hydrogenated lard is often added for the purpose. Lard stearine, the more solid portion of lard, is obtained as a byproduct during the manufacture of edible lard oil. Hydrogenated lard is made by the catalytic hydrogenation of lard and subsequent deodorization. Some experience is necessary to get the best results, because both of the agents frequently vary in their hardening powers, and the consistency of the lard changes from time to time.

A degree of firmness also can be got by a uniform blend of the fat of internal organs and the outer parts of the carcass, the cutting fat, which is less firm than the former.

Closely associated with the physical properties of a fat is its creaming power—meaning its ability to retain a large percentage of air incorporated in a dough or batter in which it is being used. The creaming power seems to be associated with the power of the fat to take up and form stable emulsions with water. Generally speaking, lard does not cream well. It lacks high emulsifying powers. Both properties may be substantially improved by limited hydrogenation of the lard or by the addition of a small percentage of hydrogenated lard. It is also possible to improve the creaming properties of fats by adding emulsifying agents, of which the monoglycerides are the outstanding example. Monoglycerides may be made from lard by reacting it with an excess of glycerol.

Several processes are available for reducing or eliminating undesirable color, odor, and free acidity. To prevent development of excessive color and odor, the fat tissues must not come into contact with dirty and inedible parts of the carcass. Care must be taken to exclude blood, muscle tissue, detached skin, and large blood vessels from the rendering kettle. Prompt chilling of the tissue also will minimize the formation of free fatty acid, which results from enzymatic and hydrolytic action. Only prompt chilling and rendering of a fat will give products having the desirable low content of free fatty acid. Too much fatty acid causes a high smoke point.

Often the color of a lard can be improved by treating the fat with an adsorptive agent like carbon or bleaching clays. Such a refining treatment is combined with the rendering operation in the so-called drip-rendering process. In it, the fat is charged into a rendering tank with a false bottom, through which the lard drains away as soon as it separates from the tissues. In this way, the time of contact between hot fat and tissue is minimized. The melted fat is then mixed with carbon in the lower part of the tank.

Several new methods for rendering fatty tissues are undergoing evaluation and development. Special emphasis is being given to quick rendering and simultaneous removal of fat and water from the raw tissues without the long heating at high temperatures used in the older methods. Fine grinding of the fat tissues, use of proteolytic enzymes, dilute caustic solutions, centrifugation, and solvent extraction have been claimed by various investigators to facilitate the rendering. In general, lard made by these quick-rendering methods has somewhat greater stability, better color, and is more bland than lard made by the older procedures.

It is hardly to be expected that treatment with adsorbents or modifications of the rendering process will produce lard as free from odor and flavor as that obtained by vigorous steam deodorization under vacuum, which is the only commercial process now feasible for producing the bland products that the modern housewife apparently wants. Equipment is available for deodorizing lard in either a batch or continuous manner. In general, the treatment consists in subjecting the hot fat to the action of steam under a high vacuum. The exact time varies from a few minutes to a few hours, depending on the type and efficiency of the equipment. Because the fatty acids are somewhat volatile under the conditions used in deodorization, a significant reduction in free fatty acids may be effected during the operation. This raises the smoke point to the highest possible level, a desirable quality in a fat used for frying.

Because lard has reasonably satisfactory properties, producers have tended to consider it a finished product. Lard, though, has been losing ground in the competitive race with hydrogenated vegetable shortenings, which once were substitutes but are now generally considered to be setting the pace. Recently lard has begun to receive more technological and scientific attention; the results are the marketing of improved products and satisfactory methods for use by the farmer in improving home-rendered lard.

WALDO C. AULT *was educated at Ohio State University. After 7 years of experience in industrial research, he joined the staff of the Northern Regional Research Laboratory and, later, the Eastern Regional Research Laboratory, where he now is head of the oil and fat division.*

ROY W. RIEMENSCHNEIDER *was trained at Illinois College, University of Illinois, and University of Maryland. He joined the Department of Agriculture in 1930. Since 1941 he has been in charge of the composition and quality section of the oil and fat division at the Eastern Laboratory.*

STEWARD G. MORRIS *entered the Department of Agriculture in 1936 and has been with the Eastern Laboratory since 1940. He has been engaged in synthesizing new antioxidants and in testing antioxidants and metal-deactivating compounds in lard. He has a doctor's degree from Columbia University.*